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USE OF A MULTIMISSION SYSTEM FOR COST EFFECTIVE SUPPORT OF PLANETARY SCIENCE DATA PROCESSING

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ABSTRACT

JPL's Multimission Operations Systems Office (MOSO) provides a multimission facility at JPL for processing science instrument data from NASA's planetary missions. This facility, the Multimission Image Processing System (MIPS), is developed and maintained by MOSO to meet requirements that span the NASA family of planetary missions. Although the word "image" appears in the title, MIPS is used to process instrument data from a variety of science instruments. This paper describes the design of a new system architecture now being implemented within the MIPS to support future planetary mission activities at significantly reduced operations and maintenance cost.

INTRODUCTION

The MIPS configuration that has been used to support Voyager, and Magellan flight operations, and the Galileo Earth and Asteroid encounters, is a centralized system based on DEC VAX computing equipment running under the VMS operating system. The new system is a distributed system based on the Unix operating system, with significant support provided for international scientists operating remotely from JPL. Image and data display, data management, and production of archival data products exploit recently defined industry standards to insure hardware platform independence,

making it possible to evolve the system in the future on commercially available platforms at minimal cost. Significant support of science users not located at JPL is provided by the new system design. Operations and maintenance costs of the new system will be significantly less than the centralized system that has been in use for approximately ten years. The VICAR software system provides instrument data processing capabilities on the new system. Commercially developed software is also available, augmenting the VICAR capability that has evolved over the past 20 years to support specific requirements for planetary exploration data analysis.

HARDWARE SYSTEM DESIGN

Figure 1 shows the hardware configuration that will be in place in time to support flight operations of the Galileo spacecraft in late 1995. The system will also be supporting calibration and system level testing of the Imaging Science Subsystem (ISS) for the Cassini mission to Saturn and final ground data system testing for the Mars Pathfinder mission during that same period of time.

The main subsystems of the new system include the following:

- Dual DEC Alpha processors that support processing of telemetry data in real time as received from the spacecraft, and production of Experiment Data Records in near real time.

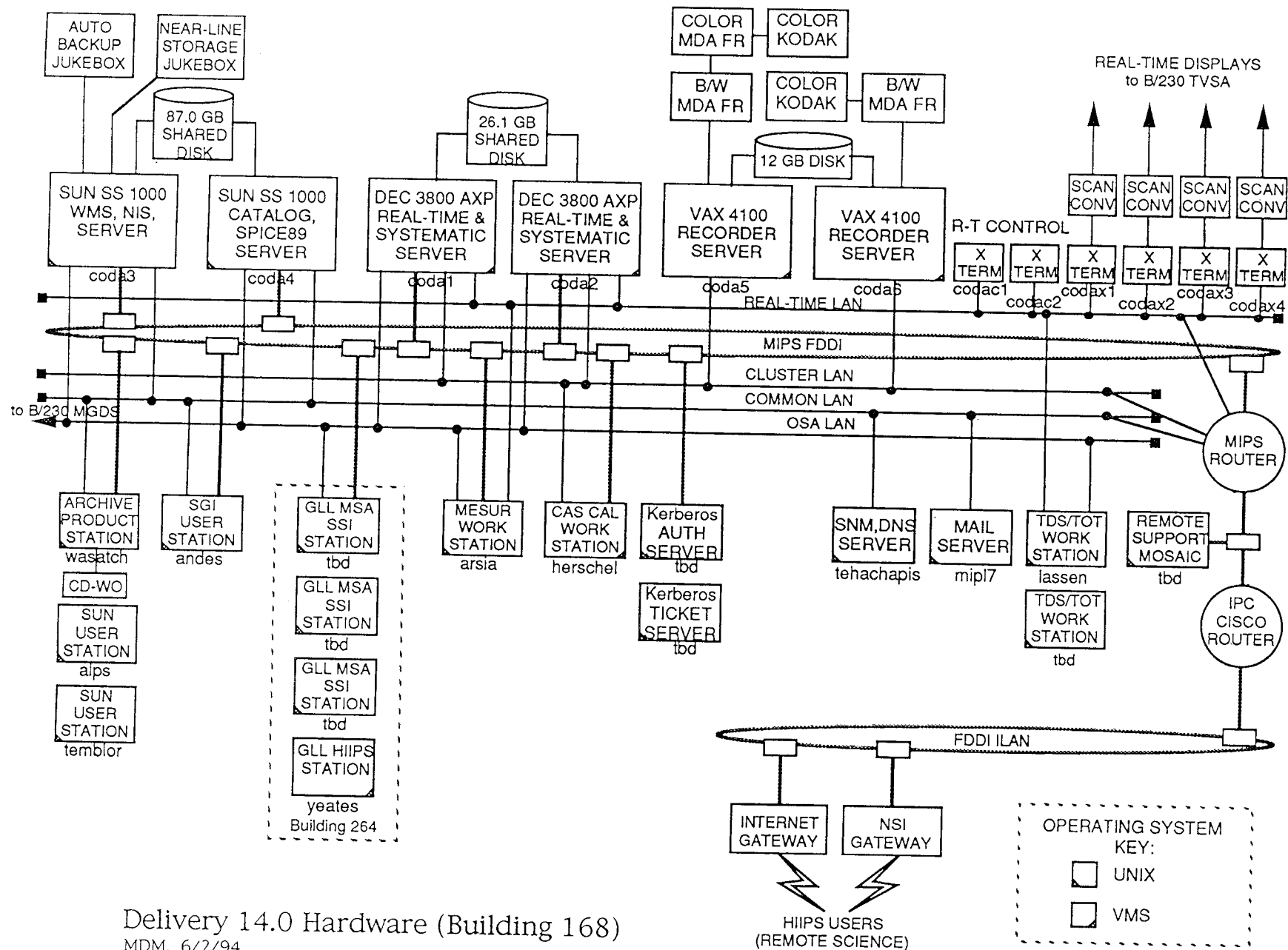


Figure 1

- Dual Sun SparcStations that are used to host a data management system that develops and maintains catalogs that contain information regarding all versions of data processed by the system and the location of each version of data processed on the system. One of the servers also manages the system's mass data storage components.
- Dual VAXStations, that support CSI black and white and color film recorders. Image data can be forwarded to the VAXStations from any source in the system, or from remote sites, for film recording.
- A set of Unix workstations utilized by various projects for processing science instrument data from various missions.
- A set of dedicated workstations used to support single project requirements. Examples include one VAXstation used to support Cassini ISS calibration and a separate workstation that will be used to support Mars Pathfinder image processing.
- X Terminal displays, used to provide display of science instrument data in various formats during real time data acquisition.
- Network resources, including FDDI and Ethernet capability provided locally within the MIPS facility and connections to external network resources. Science teams operating remotely from JPL interface with the system through various networks and routers as shown. Real time data from

JPL's telemetry processing system is provided via an Ethernet connection.

SOFTWARE OVERVIEW

The VICAR software system developed by MIPS has been used to process planetary science data returned from NASA missions for over twenty years. The software is also used internationally by science team members involved in the NASA planetary program, and is made available to commercial organizations through NASA's COSMIC code distribution center. A modular design is used, where same general purpose software modules can be applied to data from a variety of instruments. The VICAR system is being modified to operate under Unix and will be transportable to a wide variety of hardware platforms.

There are several main components of the VICAR software system. The *executive* provides the user interface to the system, and links individual modules together to support specific data processing requirements. A *subroutine library* is available that provides a set of common routines optimized for performance when dealing with large scientific data sets. *Display software* provides support for interactive viewing and manipulation of image data.

Over 200 applications programs are available within VICAR. They include programs in the following categories:

- Arithmetic functions, including averaging, differencing, image summation, image statistics, etc.
- Instrument signature removal software, applied to data returned by instruments on NASA's planetary spacecraft
- Cartographic projection software, designed to interface

with ancillary data files containing navigation and spacecraft position data from the planetary missions and perform mapping projections as requested by the user.

- Atmospheric Feature Tracking software, providing derived velocity vectors based on observed planetary atmospheric motion.
- Data compression, providing a variety of lossless and lossy compression algorithms
- Color manipulation software, including algorithms for producing three color imagery from multispectral planetary imaging instruments.
- Filtering and mathematical transformation software.
- Georeferencing software, providing the capability of correlating remotely sensed imagery with other georeferenced data sets and map data.
- Format conversion, providing conversion between VICAR format and other popular image formats.
- Real time software, used to extract science instrument data records from telemetry data streams processed during receipt of spacecraft data.

VICAR software modules can be used as components in complex processing sequences. The system utilizes a common internal image format, and each program reads and writes data files in the common format. Examples of two processing sequences for the Galileo Solid State Imaging (SSI) and Near Infra-Red Mapping Spectrometer (NIMS) instruments are shown in Figures 2 and 3.

Figure 2 shows the sequence of processing used to produce color images from Galileo SSI image data. The SSI includes a set of spectral filters, and each image is exposed through a separate filter. The spacecraft moves between successive exposures, so it is necessary to register each of the component images to a common geometric reference to create a color composite image. The spectral filters used in the SSI do not correspond to the red-green-blue response of color film or video. It is necessary to perform radiometric processing to obtain transform instrument signal data into physical radiance coordinates, and to then generate a red-green-blue composite color image. Figure 2 indicates three possible products generated from this processing sequence, including color images with high frequency detail enhanced, color ratio images, and images containing the best estimate of radiometrically correct color based on instrument calibration.

Figure 3 shows the processing sequence used to produce a visualization film product of a NIMS data set. Here, software modules specifically designed to process data acquired by spectral instruments that record hundreds of spectral bands of data over a limited region of the surface are used to construct spectral plots and a photographic rendition of this type of data.

Both the processing sequences shown in Figures 2 and 3 can be utilized on other missions flying similar instruments. The only modifications necessary are those required to format the data for display to accommodate mission specific annotation, and any changes required to accommodate differences between specific instrument designs. These sequences illustrate the modular "building block" approach to VICAR design that enables construction of complex processing sequences using individual applications programs. They also illustrate the multimission nature of the software, where common modules can be used to process data acquired by different instruments from different missions.

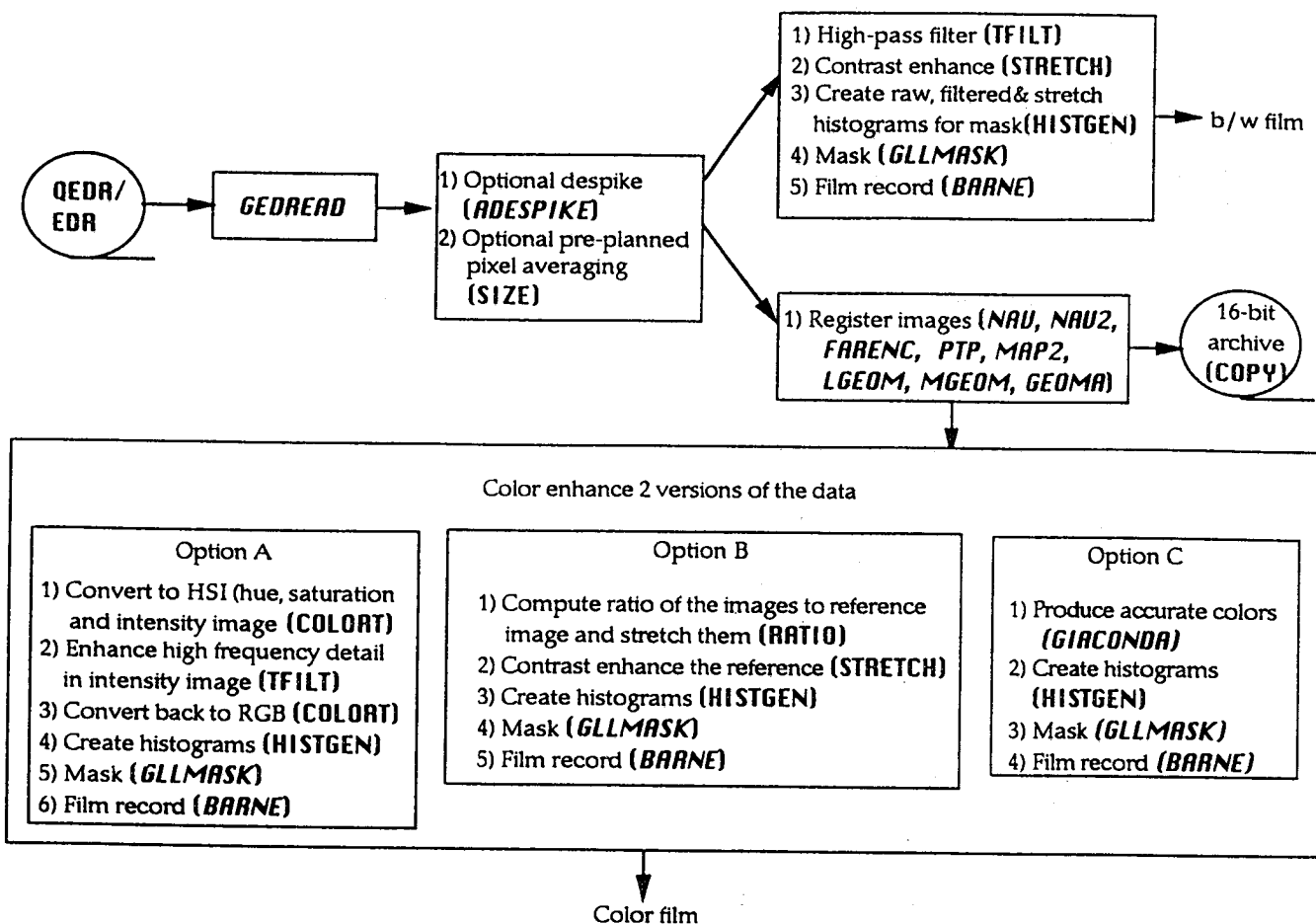


Figure 2

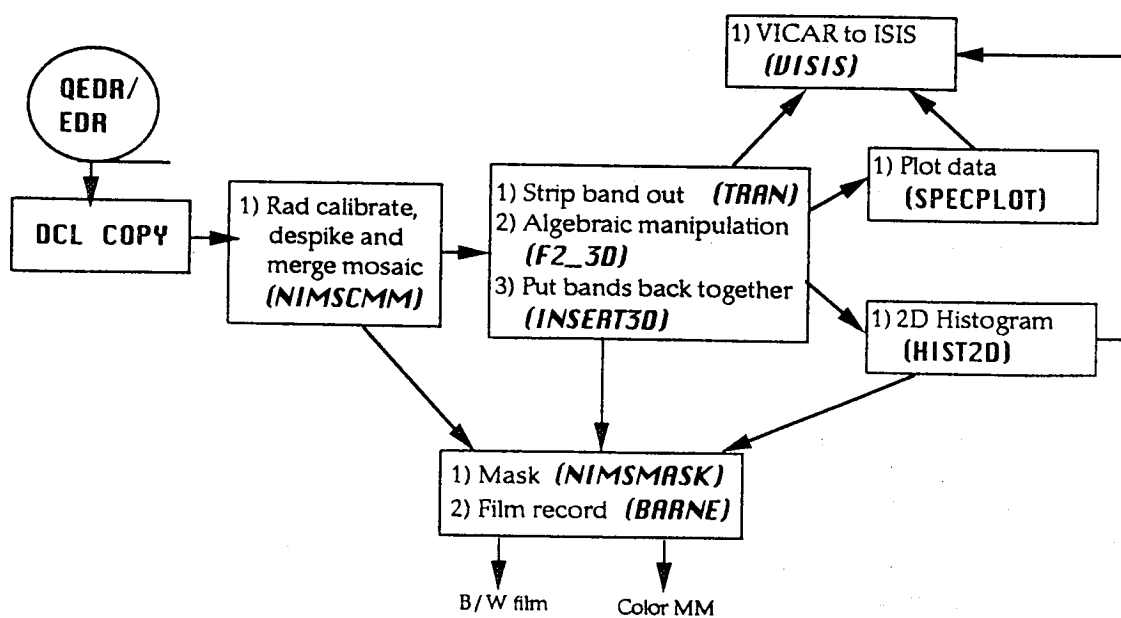


Figure 3

Figure 4 shows a typical standard Galileo black and white photoproduct generated using multimission software adapted for specific Galileo project needs. The Galileo science teams determine the format and content of the annotation information on the photoproducts. The data used to annotate photoproducts is obtained from ancillary data files (navigation data, for example) and from the engineering telemetry data stream. A multimission set of subroutines is used to create the photoproduct shown in Figure 4. Figure 5 shows one example of a photoproduct format being considered for use on Mars Pathfinder's Lander camera data. This is a preliminary format and is still undergoing change and modification based on interactions with the science team. The Mars Pathfinder photoproduct was generated using the same multimission subroutine library to build a mission specific format. With this approach, it is possible to develop prototype formats rapidly, and to complete development of photoproduct generation software with a minimum of effort for each new project.

SUMMARY

The new MIPS system provides a hardware and software system that is modular, flexible and adaptable to new requirements at minimal adaptation cost. The hardware configuration is modular and can be scaled up to handle major missions returning large quantities of data at high data rates, and provides the flexibility of accommodating missions with low data volumes through the use of dedicated workstations. The VICAR software system is also modular and adaptable to new mission requirements at low development cost.

Many principal investigators are finding it cost effective to utilize this multimission facility with established equipment, software, and interfaces with the telemetry processing system to generate first level data records for their instruments and to support other data processing requirements

using inherited software or the shared use of equipment and facilities at JPL.

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IMAGE SCENE

IMAGE DESCRIPTION SCOUT Image of pair
 IMAGE ACQUISITION TIME 03-00-0590; 12-30-003
 FIELD OF VIEW 36.2 degrees
 CAMERA POINTING 36.5 degrees from North
 INCIDENCE ANGLE 36.5 degrees
 EMISSION ANGLE 34.2 degrees

"Image of River tracks as day three of Rover's first
 excursions; region near rock cluster 23-022."

INTERCEPT STATISTICS

OPTICAL AXIS at Time sampled (SEC) 130
 ICE TEMPERATURE NONE
 DEPOSITION SYSTEM AUTO
 DEPOSITION DELAYTIME 2500.5 sec
 FILTER SYSTEM BLUE

IMAGE COMPRESSION STATISTICS

COMPRESSION RATIO	5.41
COMPRESSION RATE	1.48 bits/pixel
ENCODING TYPE	JPEG DCT
DC TABLE	5
AC TABLE	3
C TABLE	4

103